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Mesh Wireless Sensor Network: Prospects and Difficulties

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ABSTRACT: Network technology are evolving quickly these days. The physical expansion of networks, the increasing amount of information being sent (video, data, VoIP, etc.), and inter-network traffic are compelling manufacturers to create increasingly intelligent and potent devices that employ new techniques of Data sorting and transfer. These interconnected smart devices (IoT) are utilized in smart cities for water and power, in smart homes for in-home automation, and in Vehicle Ad hoc Networks (VANET) for intelligently controlled traffic for self-driving cars. These connected Internet of Things (IoT) gadgets take advantage of various network architectures. These Internet of Things sensor devices can be set up using a wireless sensor network (WSN) topology. Wireless Mesh Networks (WMNs) and WSNs are both simple to set up and implement. There are numerous justifications for mixing these various These days, network technologies are evolving at a very fast pace. The increasing amount of data, VoIP, video, and other transmitted information, the physical expansion of networks, and inter-network traffic are pushing manufacturers to create smarter and more powerful devices that use new techniques for data sorting and transfer. These connected Internet of Things (IoT) devices are used in intelligently controlled traffic for self-driving cars in Vehicle Ad hoc Networks (VANET), in smart cities for electricity and water, and in smart homes for in-home automation. These connected IoT sensor devices can be deployed as a wireless sensor network (WSN)in a mesh topology.

KEYWORDS: IoT, wireless mesh network, wireless sensor network, wireless mesh sensor network

I. INTRODUCTION

The idea of enabling computers to perceive information without human interaction was first presented to the public in 1999 for supply chain management [1], and it has since been widely extended to various domains like healthcare (COVID-19), the home, the environment, and transportation, as well as education, agriculture, and other IT domains like Blockchain and others [2] [22]. Experts estimating the Cisco Annual Internet Report predict that by 2023, people, machines, and objects will generate data volumes of up to 850 zettabytes, while the IP traffic of the global data centre will only reach 21 zettabytes [23]. By 2025, 55% of the data generated by the IoT will be stored, processed, analysed, and used close to or at the network's edge By 2021, 60 billion things will be online, according to Cisco Internet Business Solutions Group projections [25] But the tech sector is already completely The Internet of Things has embraced this, bringing with it the prerequisites for connectivity and, frequently, security [26], [27].Certain Internet of Things applications might need extremely quick reaction times, others might include private information, and some might generate a lot of data, all of which could put a significant strain on networks [28]–[31].Routing protocols play an important part in how wireless networks operate. Over the past few decades, the IT industry has seen a significant increase of wireless devices and their mobile networks. This sparked worries about the reality that Prior research was done on Mobile Ad hoc Networks (MANETs) and their routing algorithms [32]–[37]. They maximize the utilization of network resources, including memory, CPU time, power usage, and so on [38]–[41]. This indicates that maximizing the network's lifespan is possible through the deployment of efficient routing techniques. For example, as shown in Figure 1, authors in [42] suggest a Multicast protocol that uses the fuzzy logic technique [43]–[46] to enhance QoS in mobile ad hoc networks. The network architecture that IoT devices can be constructed of can have a variety of topologies, including mesh, star, point-to-point, ring, or a combination of them carrying out different planned activities like

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monitoring, environment sensing, etc. However, the hybrid of the aforementioned strategies is no longer in use. Thus, this article's goal is to list the issues that arise when attempting to connect WSN and WMN and investigate the many approaches that can be taken to accomplish so. Our focus is on identifying important issues that need to be addressed in order to completely implement highly efficient connection solutions.

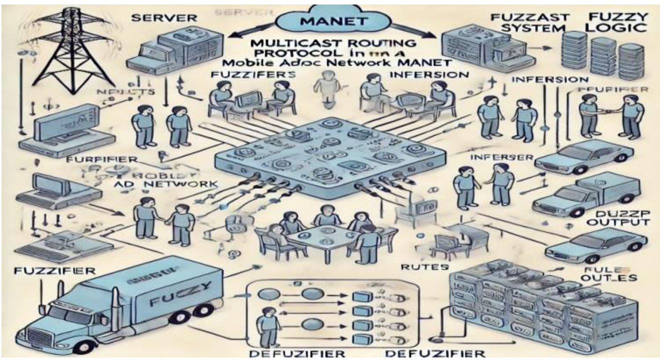

Figure 1. Multicast routing protocol in MANET and Fuzzy logic system

II. WHAT IS WIRELSS? NETWORK OF MESH SENSORS

All kinds of electrical gadgets, including LED strips, street lights, air quality monitors, and even an Internet-connected microwave oven, will eventually be included in the Internet of Things (IoT) and serve as both data generators and customers [53] through [56]. It is also reasonable to predict that, in a few years, there will be over a billion items at the network's edge. Because of this, the initial data generated by these devices will be so large that standard sensor networks will not be able to process it all effectively [57]–[62]. This implies that the data produced by the Internet of Things will put an enormous strain on the network components attempting to send data to the network's end users

A. WHY DO WE NEED MESH NETWORK?

Mesh networks are cellular radio networks with fixed wireless routers that create a wireless highway and a service area for mobile and fixed subscribers. These networks have a decentralized design with multiple switches, and these characteristics are of interest to research on functions like mobile and fixed subscribers having access within a zone of radio communication to one of the routers [64]–[68]. Mesh communications has become a very popular networking solution today [69]–[74].minimal infrastructure support for connectivity, scalability, work distribution, and inter-node communication. Network nodes are a component of the infrastructure in Wintney produce, and their main function is to carry out routing tasks. Mesh nodes have little to no mobility and typically have more processing power, memory, and bandwidth than conventional dedicated network nodes

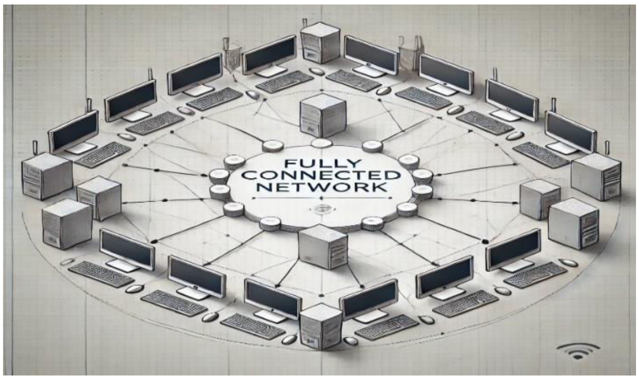

Figure 2. Wireless mesh network topology

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B. Describe the Sensor Network.

On the other hand, the foundation of wireless sensor networks is the idea that sensor devices should communicate with one another. These gadgets are renowned for being inexpensive and compact, while at the same They suffer from a limited power supply, comparatively poor computing power and memory, and a relatively low communication bandwidth [82]–[95]. When affixed to moving objects, certain sensors might be highly mobile, whilst others are immobile and motionless. The majority of research on this kind of network has concentrated on low-processing and energy-efficient routing [96]–[100].WSNs come in a wide variety of forms, ranging from sophisticated multi-hop sensor networks to crude single-hop data gathering systems. The latter kind of network can offer the greatest range and enable the use of aof sophisticated methods that modify packet routing in response to extra application requirements or supply sensory values on demand [101]–[104].

A few hundredths of basic sensors with radio receivers make up wireless sensor networks. They are frequently employed to automate and monitor vast areas. Due to their simplicity, these networks frequently experience issues with scalability and available bandwidth, and they quickly run out of energy. Currently, the only way to address these issues is to add more receivers to the network [105]–[109].Currently, wireless sensor network technology is being used more and more successfully in automation systems to monitor the condition of items. Almost any data collecting system can incorporate low-power, compact sensor equipment for technological and industrial applications.

C. WIRELESS MESH SENSOR NETWORK WHAT IS IT?

Conventional WSNs are made up of a number of sensor nodes, and one or more central devices known a "sinks", whereas these central devices are linked to a database and/or external control server that authorized users may access to look up raw or interpreted data. Unprecedented demand for large-scale WSNs with many thousands of nodes is being driven by new paths of WSN applications, such as intelligent transportation systems, urban surveillance [53], or wireless building automation, which inadvertently increase the number of hops to the destination. Adding more receiver sink nodes to the network can address this expanding issue and continuously improve scalability, as has been covered in earlier studies by a number of authors as stated in. Data is delivered to the management server once receiving sink nodes are connected.

Nonetheless, it is questionable if such a conventional data collection method—from node sensors to receivers and from receivers to the backbone—can result in very inefficient routing. Therefore, a wireless mesh network is a more practical and appropriate choice to connect receiver sink nodes due to its autonomous deployment features and robust connectivity at a wide scale. Stated differently, mesh networks can be employed when the network's shape or structure prevents every node from being within range of its ultimate destination. In other words, different sensor networks and sensor nodes can be connected via the mesh network. either as a scalable backbone or infrastructure for sensor-to-sensor communication, or to a monitoring platform. Environmental sensing is one of these uses.

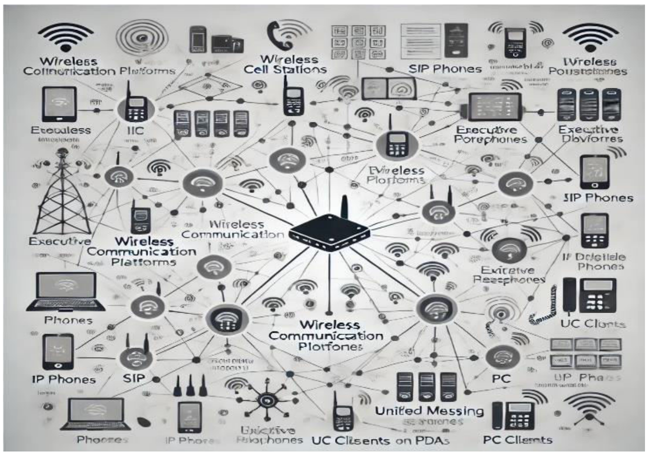

Figure 3. Wireless mesh sensor Network

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III. CASE STUDY

In order to further demonstrate our point of view on Wireless Mesh Sensor Networks, we continue our work in this section by presenting a number of case cases where the network could excel.

A. SMART HOUSE

The home environment will tremendously benefit from the Internet of Things. Numerous devices have been created and put on the market, including robotic vacuum cleaners, smart lights, and smart televisions . However, a smart home requires more than just connecting a Wi-Fi module to an existing electrical gadget. Cheap wireless sensors and controllers need to be placed in a room, pipe, and even on the wall and floor in a smart home setting in addition to a connected device. These devices will convey a remarkable quantity of information, and given The WMSN topology can be ideal for building a home with a smart environment around a gateway running a dedicated operating system (OS) in the home, improving conditions for connecting things and managing the home itself. The data could be processed locally, reducing the load on the bandwidth of the external network, and the service could be deployed to the OS for better management and delivery. This feature makes the general wireless mesh sensor network infrastructure paradigm suitable for the smart home due to the pressure to transport data and protect privacy.

Figure 4. IoT smart home network

B. SMART CITY Statistics show that over 41% of all traffic accidents in developed nations occur at intersections, with 27% of these accidents occurring there without stop signs, traffic lights, or road controls and 39% occurring there with stop signs present. To address the issue of preventing or monitoring and controlling traffic accidents, a wireless cellular mesh sensor network can be used, with each device consisting of a radio module, a rechargeable lithium-ion battery, and an anisotropic magnetoresistance circuit for vehicle detection. When the vehicle A specially created vehicle tracking algorithm can track the trajectories of vehicles crossing a specific intersection and record the total number of vehicles at the intersection based on the recorded data. The sensor device moves over the wireless node, records the detection, and sends this record to the WMSN coordinator, marking the time stamp. The WMSN coordinator is empowered to register vehicle sightings recorded by each node in the WMSN.

Figure 5. Wireless VANET smart transport infrastructure.

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C. ANALYTICS OF VIDEO

Video analytics is a new technology as a result of the widespread use of mobile phones and network cameras.Resilient and dependable network infrastructure working together can provide good opportunities for applications requiring video analytics, providing low latency and privacy concerns. Here is a fantastic example of discovering a lost youngster in the city. These days, you may observe the extensive employment of various camera types in both metropolitan regions and every automobile. It’s possible that the toddler was caught on video as he vanishes. It is quite challenging to use the camera's global data since camera data is typically not uploaded to external storage and processing sources owing to privacy or bandwidth concerns. However, even if the data that was stored were uploaded and retrieved from an outside source, after which it might take a while to load, download, and conduct more searches across such a vast volume of data, rendering this approach unsuitable for use. A search query for a missing child might potentially be created from an external source and sent to all smart devices in that target area, including roadside infrastructure elements, if an edge computing paradigm is integrated into a reliable wireless network like WMSN. Any intelligent device, like a smartphone, can run a query, look up information from its built-in camera, and send only the findings back to an outside source. This approach enables considerably faster outcomes by utilizing the data and computing capacity of anything. The ideological example of the video analytics on RIE is shown in Figure 6. For instance, there are pricey road camera versions available that may network comparable model variations and either use the camera as a base station or require a separate base station. Vendors like Cuddle back

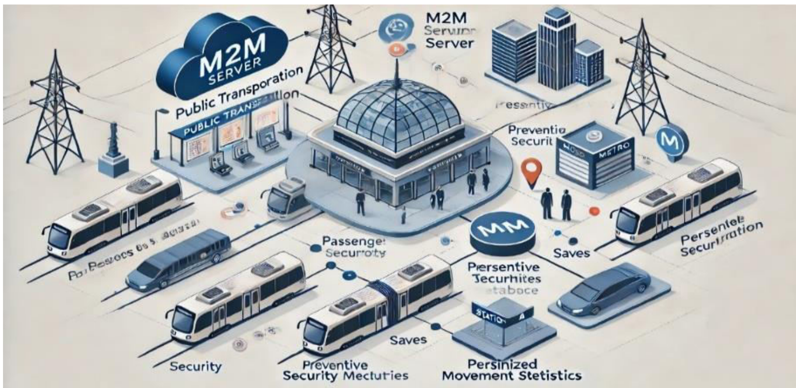

Figure 6. Passenger traffic control in public transport.

D. AI-POWERED INTELLIGENCE

The study of artificial intelligence (AI) systems first emerged in the middle of the previous century. Man-made Intelligence systems refer to a wide range of cutting-edge technologies that give machines the capacity to learn, adjust to changing circumstances, make decisions, and alter their behaviour. The sensory systems can make use of several of these skills. Numerous potent tools have been developed up to this point, including neural VOLUE 10 networks, fuzzy logical elements, genetic algorithms, expert systems based on predetermined scenarios, automatic knowledge collection systems, knowledge base systems, external intelligence technology, etc.. These tools can be used in sensor systems for the automatic resolution of issues that would otherwise require human involvement. These tools or techniques need little processing power and can be deployed on basic microcontrollers in arrays, single sensors, or small sensor systems .Advances in machine intelligence guarantee smooth communication between people and digital sensory systems, and AI systems are always getting better. AI offers flexibility, personalization, and excellent reliability, despite its sluggish introduction into electronic products. This system is becoming more and more ingrained in daily life. Additionally, there will be a lot of new uses for intelligent sensor systems in the future. As seen in Figure 10, hybrid solutions that incorporate multiple of the aforementioned technologies are likely to be preferred. Data mining methods, multi-agent systems, and distributed self-organizing systems are other technical advancements that are anticipated to have an impact on sensory systems. Furthermore, innovative AI approaches

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IV. CHALLENGES AND OPPORTUNITIES

We discussed a number of possible uses for wireless mesh sensor networks in the previous section. We contend that in order to achieve WMSN aspirations, systems and network communities need to collaborate more closely. If the system can adapt to changes and respond to obstacles, any network can operate at its best. The positioning of the sensors and the potential for strong connectivity must be considered during network implementation in order to reach the degree of effective flexibility of a certain system. Making ensuring that intelligent application software is integrated into the nodes at the network's edge is one of the greatest ways to create a good network. Every gadget must be aware that there is a communication breakdown. in order for the information they gather to last until a connection is successfully made. More reliability is ensured by adding "intelligence" at the node level, allowing the node that detects a water leak to cut off the water supply until the leak is fixed. Additionally, even if the node is now out of range, the device will still function. These nodes have the ability to function both separately and in a network. Some autonomy is granted to nodes. The ability to control and update linked network devices is the last characteristic of a strong, well-constructed wireless sensor network. Updating the software that is included into the sensor device might restore or enhance its security or even introduce new functions. The improvements give the sensor network a degree of "future-proofing" and guarantee a notable degree of adaptability in contrast to traditional wired systems, which are unable of evolving.

Figure 7. AI sensor

V. DISCUSSION AND TAXONOMY

We can infer from this study that the cohabitation of two distinct networks, whether they are united, emerging, or connected, can resolve and enhance the issues encountered during their distinct, isolated life. Reviewing research articles that concentrate on combining various target networks to cooperatively address issues that cannot be resolved by a single network type was the goal of this study part. Every network has a distinct purpose and architecture, and they are all made to serve particular functions. This implies that some network types are unable to satisfy the impending improvement requirements when goals are increased or upgraded and the network needs to be enhanced. Therefore, we believe that when networks with various functions appear in one and their topology changes, it can result in the resolution of issues that separate networks are unable to handle. In this study, we examined several previous research projects that employ a variety of networking technologies in their combined form, as shown in Figure 11's classification scheme. We came to the conclusion that linking various network types is a good way to enhance network performance in terms of scalability, bandwidth, energy efficiency, dependability, and security after analysing the study that was done.

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VI. CONCLUSION

The ability to essentially monitor everything from anyplace was made possible by the combination of inexpensive, energy-efficient technologies. Complexity arises from the consistency of sensors. Situations where the amount of data collected may make analysis challenging and where increasing demands may quickly render sensor networks obsolete. By providing a platform for new sensors and updates, as well as for bug fixes required to maintain the sensor network current, careful planning and integration of wireless sensor devices with microcontrollers can help prevent those issues. However, integrating technologies like sensor and mesh channels is both difficult and straightforward because to differences in transmission technology, routing protocols, neighbour detection, performance measurements, and power needs. Additionally, regrettably, due to such challenging issues, a large number of the aforementioned tasks are still unresolved. Questions ranging from the creation of broadcast protocols to the defining of global routing metrics accompany these activities. However, it is reasonable to assume that the metrics that distinguish these sensor and mesh networks will eventually disappear. As a result, WSN and WMN will eventually converge, necessitating the creation of flexible network protocols that are appropriate for networks with a wide variety of nodes. Moreover, data from Mordor Intelligence suggests that WMSN technology would be widely adopted in the consumer market in the upcoming years due to several ways. According to Mordor Intelligence's analysis, roughly 48% of wireless devices will be in use by 2026. and cities, artificial intelligence, large-area monitoring, and video analytics. Power management, connectivity, dependability, scalability support, interoperability, self-organizing, end-to-end reliability, privacy and security, and mobility support are some of the issues and possibilities we highlighted as being worth addressing. Research in this field was discussed. Additionally, we hope that this study will raise community awareness of this.

REFERENCES

[1] K. Ashton, "That Internet of Things thing," *RFID J.*, vol. 22, no. 7,pp. 97–114, Jun. 2009.

[2] A. K. Gupta and R. Johari, "IoT based electrical device surveil-lance and control system," in *Proc. 4th Int. Conf. Internet Things:Smart Innov. Usages (IoT-SIU)*, Apr. 2019, pp. 1–5, doi: 10.1109/IoT- SIU.2019.8777342.

[3] M. Khan, B. N. Silva, and K. Han, "Internet of Things based energy aware smart home control system," *IEEE Access*, vol. 4, pp. 7556–7566, 2016,doi: 10.1109/ACCESS.2016.2621752.

[4] S. K. Vishwakarma, P. Upadhyaya, B. Kumari, and A. K. Mishra, "Smart energy efficient home automation system using IoT," in *Proc. 4th Int. Conf. Internet Things, Smart Innov. Usages (IoT-SIU)*, Apr. 2019, pp. 1–4, doi: 10.1109/IoT-SIU.2019.8777607.

[5] H. Aamer, R. Mumtaz, H. Anwar, and S. Poslad, "A very low cost, open, wireless, Internet of Things (IoT) air quality monitoring platform," in *Proc. 15th Int. Conf. Smart Cities: Improving Qual- ity Life Using ICT IoT (HONET-ICT)*, Oct. 2018, pp. 102–106, doi:10.1109/HONET.2018.8551340.

[6] S. Dhingra, R. B. Madda, A. H. Gandomi, R. Patan, and M. Daneshmand, "Internet of Things mobile-air pollution monitoring system (IoT- Mobair)," *IEEE Internet Things J.*, vol. 6, no. 3, pp. 5577–5584, Jun. 2019, doi: 10.1109/JIOT.2019.2903821.

[7] A. Saxena, K. Shinghal, R. Misra, and A. Agarwal, "Automated enhanced learning system using IoT," in *Proc. 4th Int. Conf. Internet Things: Smart Innov. Usages (IoT-SIU)*, Apr. 2019, pp. 1–5, doi: 10.1109/IoT- SIU.2019.8777711.

[8] M. M. Raikar, P. Desai, M. Vijayalakshmi, and P. Narayankar, "Upsurge of IoT (Internet of Things) in engineering education: A case study," in *Proc. Int. Conf. Adv. Comput., Commun. Informat. (ICACCI)*, Sep. 2018, pp. 191–197, doi: 10.1109/ICACCI.2018.8554546.

[9] V. Puranik, Sharmila, A. Ranjan, and A. Kumari, "Automation in agriculture and IoT," in *Proc. 4th Int. Conf. Internet Things, Smart Innov. Usages(IoT-SIU)*, Apr. 2019, pp. 1–6, doi: 10.1109/IoT-SIU.2019.8777619.

[10] P. Srinivasulu, M. S. Babu, R. Venkat, and K. Rajesh, "Cloud service oriented architecture (CSoA) for agriculture through Internet of Things (IoT) and big data," in *Proc. IEEE Int. Conf. Electr., Instrum. Commun. Eng. (ICEICE)*, Apr. 2017, pp. 1–6, doi: 10.1109/ICEICE.2017.8191906.

[11] P. Yadav and S. Vishwakarma, "Application of Internet of Things and big data towards a smart city," in *Proc. 3rd Int. Conf. Internet Things: Smart Innov. Usages (IoT-SIU)*, Feb. 2018, pp. 1–5, doi: 10.1109/IoT- SIU.2018.8519920.

[12] S. A. Shah, D. Z. Seker, M. M. Rathore, S. Hameed, S. Ben Yahia, and D. Draheim, "Towards disaster resilient smart cities: Can Internet of Things and big data analytics be the game changers?" *IEEE Access*, vol. 7, pp. 91885–91903, 2019, doi: 10.1109/ACCESS.2019.2928233.

[13] T. A. Malapane, "The impact of artificial intelligence and

Internet of Things in the transformation of E-business sector," in *Proc. Syst. Inf. Eng. Design Symp. (SIEDS)*, Apr. 2019, pp. 1–5, doi: 10.1109/SIEDS.2019.8735644.

[14] J. Fox, A. Donnellan, and L. Doumen, "The deployment of an IoT network infrastructure, as a localised regional service," in *Proc. IEEE 5th World Forum Internet of Things (WF-IoT)*, Jan. 2019, pp. 319–324, doi: 10.1109/WF-IoT.2019.8767188.

[15] M. A. Lopez Pena and I. Munoz Fernandez, "SAT-IoT: An architectural model for a high-performance fog/edge/cloud IoT platform," in *Proc. IEEE 5th World Forum Internet Things (WF-IoT)*, Apr. 2019, pp. 633–638, doi: 10.1109/WF-IoT.2019.8767282.

[16] P. Mendki, "Docker container based analytics at IoT edge video analytics usecase," in *Proc. 3rd Int. Conf. Internet Things, Smart Innov. Usages (IoT-SIU)*, Feb. 2018, pp. 1–4, doi: 10.1109/IoT-SIU.2018.8519852.

[17] Y.-S. Jeong, "Blockchain processing technique based on multiple hash chains for minimizing integrity errors of IoT data in cloud environments," *Sensors*, vol. 21, no. 14, p. 4679, Jul. 2021, doi: 10.3390/s21144679.

[18] S.-H. Sim and Y.-S. Jeong, "Multi-blockchain-based IoT data processing techniques to ensure the integrity of IoT data in AIoT edge comput-ing environments," *Sensors*, vol. 21, no. 10, p. 3515, May 2021, doi: 10.3390/s21103515.

[19] A ufail, A. Namoun, A. A. Sen, K. Kim, A. Alrehaili, and A. Ali, "Moisture computing-based Internet of Vehicles (IoV) architecture for smart cities," *Sensors*, vol. 21, p. 3785, Oct. 2021, doi: 10.3390/s21113785.

[20] P. Marin-Plaza, D. Yagée, F. Royo, M. de Miguel, F. Moreno, A. Ruiz-de-la-Cuadra, and F. Viadero-Monasterio, "Project ARES: Driverless transportation system. challenges and approaches in an unstructured road," *Electronics*, vol. 10, p. 1753, Oct. 2021, doi: 10.3390/electronics10151753.

[21] M. Umair, M. Cheema, O. Cheema, H. Li, and H. Lu, "Impact of COVID-19 on IoT adoption in healthcare, smart homes, smart buildings, smart cities, transportation and industrial IoT," *Sensors*, vol. 21, p. 3838, Apr. 2021, doi: 10.3390/s21113838.

[22] A. Ramallo-González and A. Skarmeta, "CIoTVID: Towards an open IoT-platform for infective pandemic diseases such as COVID-19," *Sen- sors*, vol. 21, p. 484, Apr. 2021, doi: 10.3390/s21020484.

[23] *Cisco Annual Internet Report (2018-2023) White Paper*, Cisco, San Jose, CA, USA, 2020.

[24] *Redefine Connectivity by Building a Network to Support the Internet of Things*, Cisco, San Jose, CA, USA, 2019.

[25] D. Evans, "The Internet of Things: How the next evolution of the internet is changing everything," CISCO, San Jose, CA, USA, Tech. Rep., Jan. 2011. [Online]. Available: https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf

[26] R. Mozny, P. Masek, M. Stusek, K. Zeman, A. Ometov, and J. Hosek, "On the performance of narrow-band Internet of Things (NB-IoT) for delay- tolerant services," in *Proc. 42nd Int. Conf. Telecommun. Signal Process. (TSP)*, 2019, pp. 637–642, doi: 10.1109/TSP.2019.8768871.

[27] J. Hosek, P. Masek, S. Andreev, O. Galinina, A. Ometov, F. Kropfl, W. Wiedermann, and Y. Koucheryavy, "A SyMPHOnY of integrated IoT businesses: Closing the gap between availability and adoption," *IEEE Commun. Mag.*, vol. 55, no. 12, pp. 156–164, Dec. 2017, doi: 10.1109/MCOM.2017.1700028.

[28] B. Da, P. P. Esnault, S. Hu, and C. Wang, "Identity/identifier-enabled networks (IDEAS) for Internet of Things (IoT)," in *Proc. IEEE 4th World Forum Internet Things (WF-IoT)*, Feb. 2018, pp. 412–415, doi: 10.1109/WF-IoT.2018.8355102.

[29] M. Chakraborty, B. Jana, and T. Mandal, "Implementation of an efficient security scheme through elliptic curve cryptography based radio- frequency Identification(RFID) in context of Internet of Things," in *Proc. Int. Conf. Recent Innov. Electr., Electron. Commun. Eng. (ICRIEECE)*, Jul. 2018, pp. 1777–1781, doi: 10.1109/ICRIEECE44171.2018. 9008906.

[30] T. Yokotani and Y. Sasaki, "Transfer protocols of tiny data blocks in IoT and their performance evaluation," in *Proc. IEEE 3rd World Forum Internet Things (WF-IoT)*, Dec. 2016, pp. 54–57, doi: 10.1109/WF- IoT.2016.7845442.

[31] R. Giaffreda, L. Capra, and F. Antonelli, "A pragmatic approach to solving IoT interoperability and security problems in an eHealth context," in *Proc. IEEE 3rd World Forum Internet Things (WF-IoT)*, Dec. 2016, pp. 547–552, doi: 10.1109/WF-IoT.2016.7845452.

[32] S. Shruthi, "Proactive routing protocols for a MANET—A review," in *Proc. Int. Conf. I-SMAC (IoT Social, Mobile, Analytics Cloud) (I-SMAC)*, Feb. 2017, pp. 821–827, doi: 10.1109/I-SMAC.2017.8058294.

[33] H. Huang, H. Yin, G. Min, J. Zhang, Y. Wu, and X. Zhang, "Energy-aware dual-path geographic routing to bypass routing holes in wireless sensor networks," *IEEE Trans. Mobile Comput.*, vol. 17, no. 6, pp. 1339–1352, Jun. 2018, doi: 10.1109/TMC.2017.2771424.

[34] G. Ma, X. Li, Q. Pei, and Z. Li, "A security routing protocol for Internetof Things based on RPL," in *Proc. Int. Conf. Netw. Netw. Appl. (NaNA)*, Oct. 2017, pp. 209–213, doi: 10.1109/NaNA.2017.28.

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International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

[35] Z. Nurlan, T. Zhukabayeva, and M. Othman, "Mesh network dynamic routing protocols," in *Proc. IEEE 9th Int. Conf. Syst. Eng. Technol. (ICSET)*, Oct. 2019, pp. 364–369, doi: 10.1109/ICSEngT.2019.8906314.
[36] Z. Nurlan, T. Zhukabayeva, and M. Othman, "IoT hardware-defined routing protocol for dynamic self-organizing wireless mesh networks," in *Proc. IEEE 10th Int. Conf. Consum. Electron. (ICCE-Berlin)*, Nov. 2020, pp. 1–4, doi: 10.1109/ICCE-Berlin50680.2020.9352191.
[37] Z. Nurlan, T. Zhukabayeva, and M. Othman, "EZ-SEP: Extended Z-SEP routing protocol with hierarchical clustering approach for wireless het- erogeneous sensor network," *Sensors*, vol. 21, no. 4, p. 1021, Feb. 2021, doi: 10.3390/s21041021.
[38] D. Kominami, M. Sugano, M. Murata, and T. Hatauchi, "Energy-efficient receiver-driven wireless mesh sensor networks," *Sensors*, vol. 11, no. 1, pp. 111–137, Dec. 2010, doi: 10.3390/s110100111.
[39] A.-J. Garcia-Sanchez, F. Garcia-Sanchez, D. Rodenas-Herraiz, and J. Garcia-Haro, "On the synchronization of IEEE 802.15.5 wireless mesh sensor networks: Shortcomings and improvements," *EURASIP J. Wireless Commun. Netw.*, vol. 2012, no. 1, p. 54, Dec. 2012, doi: 10.1186/1687-1499-2012-198.
[40] F. Losilla, D. Rodenas-Herraiz, F. Cruz-Martinez, and F. Garcia-Sanchez, "On the feasibility of wireless multimedia sensor networks over IEEE 802.15. 5 mesh topologies," *Sensors*, vol. 16, no. 5, p. 643, May 2016, doi: 10.3390/s16050643.
[41] D. Rodenas-Herraiz, A.-J. Garcia-Sanchez, F. Garcia-Sanchez, and J. Garcia-Haro, "On the improvement of wireless mesh sensor network performance under hidden terminal problems," *Future Gener. Comput. Syst.*, vol. 45, pp. 95–113, Apr. 2015, doi: 10.1016/j.future.2014.11.012.
[42] K. U. Adhvaryu and P. Kamboj, "Performance comparison between multicast routing protocols in MANET," in *Proc. 4th IEEE Uttar Pradesh Sect. Int. Conf. Electr., Comput. Electron. (UPCON)*, Oct. 2017, pp. 16–20, doi: 10.1109/UPCON.2017.8251015.
[43] M. N. Ali, K. Mahmoud, M. Lehtonen, and M. M. F. Darwish, "Promising MPPT methods combining Metaheuristic, fuzzy-logic and ANN tech- niques for grid-connected photovoltaic," *Sensors*, vol. 21, no. 4, p. 1244, Feb. 2021, doi: 10.3390/s21041244.
[44] M. D. Hossain, T. Sultana, M. A. Hossain, M. I. Hossain, L. N. T. Huynh, J. Park, and E.-N. Huh, "Fuzzy decision-based efficient task offloading management scheme in multi-tier MEC-enabled networks," *Sensors*, vol. 21, no. 4, p. 1484, Feb. 2021, doi: 10.3390/s21041484.
[45] S. Tarannum and S. Jabin, "A comparative study on fuzzy logic and intuitionistic fuzzy logic," in *Proc. Int. Conf. Adv. Comput., Commun. Con- trol Netw. (ICACCCN)*, Oct. 2018, pp. 1086–1090, doi: 10.1109/ICAC- CCN.2018.8748844.
[46] A. Argou, R. Dilli, R. Reiser, and A. Yamin, "Exploring type-2 fuzzy logic with dynamic rules in IoT resources classification," in *Proc. IEEE Int. Conf. Fuzzy Syst. (FUZZ-IEEE)*, Jun. 2019, pp. 1–6, doi: 10.1109/FUZZ-IEEE2019.8858944.
[47] R. A. Kjellby, L. R. Cenkeramaddi, A. Fráytlog, B. B. Lozano, J. Soumya, and M. Bhange, "Long-range & self-powered IoT devices for agriculture & aquaponics based on multi-hop topology," in *Proc. IEEE 5th World Forum on Internet of Things (WF-IoT)*, Dec. 2019, pp. 545–549, doi: 10.1109/WF-IoT.2019.8767196.
[48] A. Dey, K. Stuart, and M. E. Tolentino, "Characterizing the impact of topology on IoT stream processing," in *Proc. IEEE 4th World Forum Internet Things (WF-IoT)*, Feb. 2018, pp. 505–510, doi: 10.1109/WF- IoT.2018.8355119.
[49] T. N. Nguyen, C. V. Ho, and T. T. T. Le, "A topology control algorithm in wireless sensor networks for IoT-based applications," in *Proc. Int. Symp. Electr. Electron. Eng. (ISEE)*, Oct. 2019, pp. 141–145, doi: 10.1109/ISEE2.2019.8921357.
[50] V. Shakhov and I. Koo, "Towards robust IoT network topology in adversarial environments," in *Proc. Int. Multi-Conf. Eng., Comput. Inf. Sci. (SIBIRCON)*, Oct. 2019, pp. 148–151, doi: 10.1109/SIBIR- CON48586.2019.8958240.
[51] F. Albalas, W. Mardini, M. Al-Soud, and Q. Yaseen, "A topology–based performance evaluation for an adaptive tuning protocol for service and resource discovery in the Internet of Things," in *Proc. IEEE 9th Annu. Comput. Commun. Workshop Conf. (CCWC)*, Jan. 2019, pp. 905–909, doi: 10.1109/CCWC.2019.8666465.
[52] H. Mamat, B. H. Ibrahim, and M. P. Sulong, "Network topology comparison for internet communication and IoT connectivity," in *Proc. IEEE Conf. Open Syst. (ICOS)*, Nov. 2019, pp. 1–5, doi: 10.1109/ICOS47562.2019.8975702.
[53] H.-C. Lee and K.-H. Ke, "Monitoring of large-area IoT sensors using a LoRa wireless mesh network system: Design and evaluation," *IEEE Trans. Instrum. Meas.*, vol. 67, no. 9, pp. 2177–2187, Sep. 2018, doi: 10.1109/TIM.2018.2814082.
[54] H. Yuliandoko and A. Rohman, "Flooding detection system based on water monitoring and ZigBee mesh protocol," in *Proc. 4th Int. Conf. Inf. Technol., Inf. Syst. Electr. Eng. (ICITISEE)*, Nov. 2019, pp. 385–390, doi: 10.1109/ICITISEE48480.2019.9003928.
[55] H. C. Lee and H. H. Lin, "Design and evaluation of an open-source wireless mesh networking module for environmental monitor- ing," *IEEE Sensors J.*, vol. 16, no. 7, pp. 2162–2171, Apr. 2016, doi: 10.1109/JSEN.2015.2507596.
[56] Y. Liu, K.-F. Tong, X. Qiu, Y. Liu, and X. Ding, "Wireless mesh networks in IoT networks," in *Proc. Int.*

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Workshop Electromagnet-ics: Appl. Student Innov. Competition, May 2017, pp. 183–185, doi:10.1109/iWEM.2017.7968828.
[57] C. Vuppalapati, A. Ilapakurti, and S. Kedari, "The role of big data in creating sense EHR, an integrated approach to create next generation mobile sensor and wearable data driven electronic health record (EHR)," in *Proc. IEEE 2nd Int. Conf. Big Data Comput. Service Appl. (BigDataService)*, Mar. 2016, pp. 293–296, doi: 10.1109/BigDataService.2016.18.
[58] J. R. Dinakar and S. Vagdevi, "A study on storage mechanism for heterogeneous sensor data on big data paradigm," in *Proc. Int. Conf. Electr., Electron., Commun., Comput., Optim. Techn. (ICEECCOT)*, 2017, pp. 342–345, doi: 10.1109/ICEECCOT.2017.8284525.
[59] A. C. Onal, O. Berat Sezer, M. Ozbayoglu, and E. Dogdu, "Weather data analysis and sensor fault detection using an extended IoT framework with semantics, big data, and machine learning," in *Proc. IEEE Int. Conf. Big Data (Big Data)*, Dec. 2017, pp. 2037–2046, doi: 10.1109/Big-Data.2017.8258150.
[60] D. Liu, "Big data analytics architecture for Internet-of-Vehicles based on the spark," in *Proc. Int. Conf. Intell. Transp., Big Data Smart City (ICITBS)*, Jan. 2018, pp. 13–16, doi: 10.1109/ICITBS.2018. 00011.
[61] S. Park, S. Jung, H. Lee, J. Kim, and J.-H. Kim, "Large-scale water quality prediction using federated sensing and learning: A case study with real-world sensing big-data," *Sensors*, vol. 21, no. 4, p. 1462, Feb. 2021, doi: 10.3390/s21041462.
[62] Z. Shahbazi and Y.-C. Byun, "Integration of blockchain, IoT and machine learning for multistage quality control and enhancing security in smart manufacturing," *Sensors*, vol. 21, no. 4, p. 1467, Feb. 2021, doi:10.3390/s21041467.
[63] *Wireless Sensors Network Market—Growth, Trends, COVID-19 impact, and Forecasts (2021-2026)*, Mordor Intelligence, Gachibowli Hyderabad, Telangana, India, 2020.
[64] M. J. Lee, J. Zheng, Y.-B. Ko, and D. M. Shrestha, "Emerging standards for wireless mesh technology," *IEEE Wireless Commun.*, vol. 13, no. 2, pp. 56–63, Apr. 2006, doi: 10.1109/MWC.2006.1632481.
[65] S. Pandi, S. Wunderlich, and F. H. P. Fitzek, "Reliable low latency wireless mesh networks—From myth to reality," in *Proc. 15th IEEE Annu. Consum. Commun. Netw. Conf. (CCNC)*, Jan. 2018, pp. 1–2, doi: 10.1109/CCNC.2018.8319326.
[66] W. Li and H. Bai, "A new wireless mesh network based on network coding technology," in *Proc. Int. Conf. Sensor Netw. Signal Process. (SNSP)*, Oct. 2018, pp. 35–39, doi: 10.1109/SNSP.2018.00016.
[67] S. M. Darroudi and C. Gomez, "Modeling the connectivity of data-channel-based Bluetooth low energy mesh networks," *IEEE Commun. Lett.*, vol. 22, no. 10, pp. 2124–2127, Oct. 2018, doi: 10.1109/LCOMM.2018.2864994.
[68] R. Kashyap, M. Azman, and J. G. Panicker, "Ubiquitous mesh: A wireless mesh network for iot systems in smart homes and smart cities," in *Proc. IEEE Int. Conf. Electr., Comput. Commun. Technol. (ICECCT)*, Jun. 2019, pp. 1–5, doi: 10.1109/ICECCT.2019.8869482.
[69] M. Lee, R. Zhang, J. Zheng, G.-S. Ahn, C. Zhu, T. Park, S. Cho, C. Shin, and J. Ryu, "IEEE 802.15.5 WPAN mesh standard-low rate Part: Meshing the wireless sensor networks," *IEEE J. Sel. Areas Com- mun.*, vol. 28, no. 7, pp. 973–983, Sep. 2010, doi: 10.1109/JSAC.2010. 100902.
[70] M. Gupta, Vikash, and S. Varma, "Configuration of aerial mesh networks with Internet of Things," in *Proc. Int. Conf. Wireless Commun., Signal Process. Netw. (WiSPNET)*, Mar. 2018, pp. 1–3, doi: 10.1109/WiSP-NET.2018.8538651.
[71] F. O. Sales, Y. Marante, A. B. Vieira, and E. F. Silva, "Energy consumption evaluation of a routing protocol for low-power and lossy networks in mesh scenarios for precision agriculture," *Sensors*, vol. 20, no. 14, p. 3814, Jul. 2020, doi: 10.3390/s20143814.
[72] S. R. Bassolillo, E. D'Amato, I. Notaro, L. Blasi, and M. Mattei, "Decentralized mesh-based model predictive control for swarms of UAVs," *Sensors*, vol. 20, no. 15, p. 4324, Aug. 2020, doi: 10.3390/ s20154324.
[73] S. Darroudi and C. Gomez, "Experimental evaluation of 6BLEMesh: IPv6-based BLE mesh networks," *Sensors*, vol. 20, p. 4623, Apr. 2020, doi: 10.3390/s20164623.
[74] R. Berto, P. Napoletano, and M. Savi, "A LoRa-based mesh network for peer-to-peer long-range communication," *Sensors*, vol. 21, p. 4314, Jul. 2021, doi: 10.3390/s21134314.
[75] S. U. Dixit and K. M. Patil, "Smart phone wireless ad-hoc mesh network," in *Proc. 3rd IEEE Int. Conf. Recent Trends Electron., Inf. Com- mun. Technol. (RTEICT)*, May 2018, pp. 2346–2350, doi: 10.1109/RTE-ICT42901.2018.9012362.
[76] R. Shinkuma and N. B. Mandayam, "Design of ad hoc wireless mesh networks formed by unmanned aerial vehicles with advanced mechanical automation," in *Proc. 16th Int. Conf. Distrib. Com-put. Sensor Syst. (DCOSS)*, May 2020, pp. 288–295, doi: 10.1109/ DCOSS49796.2020.00053.
[77] M. Li, T. Peng, and H. Wu, "Power allocation to achieve maximum throughput in multi-radio multi-channel mesh network," in *Proc. IEEE 6th Int. Conf. Comput. Commun. (ICCC)*, Dec. 2020, pp. 293–297, doi: 10.1109/ICCC51575.2020.9345094.
[78] X. Jiang, H. Zhang, E. A. Barsallo Yi, N. Raghunathan, C. Mousoulis, S. Chaterji, D. Peroulis, A. Shakouri, and S. Bagchi, "Hybrid low-power wide-area mesh network for IoT applications," *IEEE Internet Things J.*, vol. 8, no. 2, pp. 901–

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

915, Jan. 2021, doi: 10.1109/JIOT.2020.3009228.
[79] E. Fitzgerald, M. Pióro, and A. Tomaszewski, "Energy versus throughput optimisation for Machine-to-Machine communication," *Sensors*, vol. 20,no. 15, p. 4122, Jul. 2020, doi: 10.3390/s20154122.
[80] M. R. Ghori, T.-C. Wan, and G. C. Sodhy, "Bluetooth low energy mesh networks: Survey of communication and security protocols," *Sensors*, vol. 20, no. 12, p. 3590, Jun. 2020, doi: 10.3390/s20123590.
[81] S.-M. Zhang, S.-B. Gao, T.-K. Dao, D.-G. Huang, J. Wang, H.-W. Yao, O. Alfarraj, and A. Tolba, "An analysis scheme of balancing energy consumption with mobile velocity control strategy for wireless recharge-able sensor networks," *Sensors*, vol. 20, no. 16, p. 4494, Aug. 2020, doi: 10.3390/s20164494.
[82] A. Bojovschi, "From sensors to sensor networks: A journey of innovation," in *Proc. 2nd Int. Conf. Telecommun. Netw. (TEL-NET)*, Aug. 2017,pp. 1–11, doi: 10.1109/TEL-NET.2017.8343493.
[83] Y. Nishikawa, T. Sasamura, Y. Ishizuka, S. Sugimoto, S. Iwasaki, H. Wang, T. Fujishima, T. Fujimoto, K. Yamashita, T. Suzuki, and K. Kurihara, "Design of stable wireless sensor network for slope mon- itoring," in *Proc. IEEE Topical Conf. Wireless Sensors Sensor Netw. (WiSNet)*, Jan. 2018, pp. 8–11, doi: 10.1109/WISNET.2018.8311550.
[83] A. R. Nezhad and M. Sadeghi, "A new routing approach for performance improvement in mobile sensor networks," in *Proc. 5th Int. Conf. Comput. Sci. Netw. Technol. (ICCSNT)*, Dec. 2016, pp. 672–676, doi: 10.1109/ICCSNT.2016.8070242.
[84] S. Ezdiani, I. S. Acharyya, S. Sivakumar, and A. Al-Anbuky, "Wire-less sensor network softwarization: Towards WSN adaptive QoS," *IEEE Internet Things J.*, vol. 4, no. 5, pp. 1517–1527, Oct. 2017, doi: 10.1109/JIOT.2017.2740423.
[85] T. Kageyama, M. Miura, A. Maeda, A. Mori, and S.-S. Lee, "A wireless sensor network platform for water quality monitoring," in *Proc. IEEESENSORS*, Oct. 2016, pp. 1–3, doi: 10.1109/ICSENS.2016.7808887.
[86] W. A. Hussein, B. M. Ali, M. F. A. Rasid, and F. Hashim, "Design and performance analysis of high reliability-optimal routing protocolfor mobile wireless multimedia sensor networks," in *Proc. IEEE 13th Malaysia Int. Conf. Commun. (MICC)*, Nov. 2017, pp. 136–140, doi: 10.1109/MICC.2017.8311747.
[87] M. Alkhweld, "Optimal sensor density and placement in power-constrained wireless sensor networks," in *Proc. Int. Conf. Comput., Netw. Commun. (ICNC)*, Jan. 2017, pp. 1036–1040, doi: 10.1109/ICCNC.2017.7876277.
[88] R. Jedermann, H. Paul, and W. Lang, "Spatial processing of sensor net-work data: Demonstrator and feasibility study," in *Proc. IEEE SENSORS*,Oct. 2017, pp. 1–3, doi: 10.1109/ICSENS.2017.8233891.
[89] A. Mateen, M. Sehar, K. Abbas, and M. A. Akbar, "Comparative analysis of wireless sensor networks with wireless multimedia sensor networks," in *Proc. IEEE Int. Conf. Power, Control, Signals Instrum. Eng. (ICPCSI)*,Sep. 2017, pp. 80–83, doi: 10.1109/ICPCSI.2017.8391847.
[90] Y. Yue, H. Fan, J. Li, and Q. Qin, "Large-scale mobile wireless sensor network data fusion algorithm," in *Proc. Int. Conf. Big Data Anal.(ICBDA)*, 2016, pp. 1–5, doi: 10.1109/ICBDA.2016.7509832.
[91] P. Devan, F. Hussin, R. Ibrahim, K. Bingi, and F. Khanday, "A survey on the application of wirelesshart for industrial process monitoring andcontrol," *Sensors*, vol. 21, p. 4951, Jan. 2021, doi: 10.3390/s21154951.
[92] M. Khan, M. Bibi, F. Aadil, and J. Lee, "Adaptive node clustering for underwater sensor networks," *Sensors*, vol. 21, p. 4514, Oct. 2021, doi:10.3390/s21134514.
[93] C. Gonzalez-Amarillo, C. Cardenas-Garcia, M. Mendoza-Moreno, G. Ramirez-Gonzalez, and J. Corrales, "Blockchain-IoT sensor (BIoTS): A solution to IoT-ecosystems security issues," *Sensors*, vol. 21, p. 4388, Apr. 2021, doi: 10.3390/s21134388.
[94] C. Perra, A. Kumar, M. Losito, P. Pirino, M. Moradpour, and G. Gatto, "Monitoring indoor people presence in buildings using low-cost infraredsensor array in doorways," *Sensors*, vol. 21, p. 4062, Dec. 2021, doi: 10.3390/s21124062.
[95] C. Li, J. Li, M. Jafarizadeh, G. Badawy, and R. Zheng, "LEMoNet: Low energy wireless sensor network design for data center monitoring," in *Proc. IFIP Netw. Conf.*, 2019, pp. 1–9, doi: 10.23919/IFIPNetwork- ing46909.2019.8999456.
[96] M. Usman, D. Har, and I. Koo, "Energy-efficient infrastructure sensor network for ad hoc cognitive radio network," *IEEE Sensors J.*, vol. 16, no. 8, pp. 2775–2787, Apr. 2016, doi: 10.1109/JSEN.2016.2516018.
[97] S. Sultan, M. Waleed, J. Pyun, and T. Um, "Energy conservation for Inter-net of Things tracking applications using deep reinforcement learning," *Sensors*, vol. 21, p. 3261, May 2021, doi: 10.3390/s21093261.
[98] S. You, J. K. Eshraghian, H. C. Iu, and K. Cho, "Low-power wireless sensor network using fine-grain control of sensor module power mode,"*Sensors*, vol. 21, no. 9, p. 3198, May 2021, doi: 10.3390/s21093198.
[99] Y. Spyridis, T. Lagkas, P. Sarigiannidis, V. Argyriou, A. Sarigiannidis, G. Eleftherakis, and J. Zhang, "Towards 6G IoT: Tracing mobile sensor nodes with deep learning clustering in UAV networks," *Sensors*, vol. 21, no. 11, p. 3936, Jun. 2021, doi: 10.3390/s21113936.
[100] C.-M. Yu, M.-L. Ku, and C.-W. Chang, "Hybrid multi-hop/single-hop opportunistic transmission of WSNs," in *Proc. IEEE Int. Conf. Consum. Electron. - Taiwan (ICCE-TW)*, Jun. 2017, pp. 111–112, doi: 10.1109/ICCE-

China.2017.7991020.
[101] A. Al-Shaikhi and A. Masoud, "Efficient, single hop time syn-chronization protocol for randomly connected WSNs," *IEEE Wire- less Commun. Lett.*, vol. 6, no. 2, pp. 170–173, Apr. 2017, doi: 10.1109/LWC.2017.2650223.
[102] D. Zhang, Y. Wang, Y. Lv, and Z. Liu, "A cluster head multi-hop topology control algorithm for WSN," in *Proc. IEEE 2nd Int. Conf. Comput. Commun. Eng. Technol. (CCET)*, Aug. 2019, pp. 269–273, doi: 10.1109/CCET48361.2019.8989282.
[103] S. Z. Zakaria, A. A. Aziz, and M. Drieberg, "Multi-hop wireless sensor network for remote monitoring of soil moisture," in *Proc. IEEE 3rdInt. Symp. Robot. Manuf. Autom. (ROMA)*, Sep. 2017, pp. 1–5, doi:10.1109/ROMA.2017.8231829.
[104] A. Singh and A. Nagaraju, "Energy efficient optimal path based coded transmission for multi-sink and multi-hop WSN," in *Proc. 2nd Int. Conf. Green Comput. Internet Things (ICGCIoT)*, Aug. 2018, pp. 129–132, doi: 10.1109/ICGCIoT.2018.8752993.
[105] R. Teja and S. Indu, "A priority based WSN clustering of multiple sink scenario using artificial bee colony algorithm," in *Proc. Int. Conf. Comput. Syst. Inf. Technol. for Sustain. Solutions (CSITSS)*, Oct. 2016, pp. 130–134, doi: 10.1109/CSITSS.2016.7779409.
[106] H. R. Faragardi, H. Fotouhi, T. Nolte, and R. Rahmani, "A cost efficient design of a multi-sink multi-controller WSN in a smart factory," in *Proc. IEEE 19th Int. Conf. High Perform. Comput. Communications; IEEE 15th Int. Conf. Smart City; IEEE 3rd Int. Conf. Data Sci. Syst. (HPCC/SmartCity/DSS)*, Dec. 2017, pp. 594–602, doi: 10.1109/HPCC-SmartCity-DSS.2017.77.
[107] Z. W. Hussien, D. S. Qawasmeh, and M. Shurman, "MSCLP: Multi- sinks cluster-based location privacy protection scheme in WSNs for IoT," in *Proc. 32nd Int. Conf. Microelectron. (ICM)*, Dec. 2020, pp. 1–4, doi: 10.1109/ICM50269.2020.9331785.
[108] B. R. Al-Kaseem, Z. K. Taha, S. W. Abdulmajeed, and H. S. Al-Raweshidy, "Optimized energy— Efficient path planning strategy in WSN with multiple mobile sinks," in *IEEE Access*, vol. 9,pp. 82833–82847, 2021, doi: 10.1109/ACCESS.2021.3087086.
[109] L. Q. Zhuang, K. M. Goh, and J. B. Zhang, "The wireless sensor net-works for factory automation: Issues and challenges," in *Proc. IEEE Conf. Emerg. Technol. Factory Autom.*, Oct. 2007, pp. 141–148, doi: 10.1109/EFTA.2007.4416764.

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